



## Editorial

### Green Chemistry

Gilbert's chemistry sets, those that many of today's practicing chemists received as children, proved to be the spark that ignited many a lifelong exploration of the wonders of chemistry. While DuPont was espousing its contributions to the world with its motto, "Better living through chemistry," children were using the popular Gilbert's chemistry sets to perform the simplest experiments and viewing them as wonders to behold. The rewards for the chemists' subsequent work are obvious today. Developments in water treatment, waste disposal methods, agricultural pesticides and fungicides, polymers, materials science, detergents, petroleum additives, and so forth, have all contributed to the improvement in our quality of life. But all of these advances came with a price tag—pollution.

Scientists and engineers from both the chemical industry and the academic world have made efforts to correct pollution problems by the more extensive use of "green" chemistry concepts, i.e., development of methodologies and products that are environmentally friendly. The chemical industry itself also has instituted programs, such as Responsible Care (1), to address pollution problems. How well this program will function is still not clear, as has been addressed previously on these same pages (2).

An awareness of green chemistry concepts seems to be growing. In a recent article that was published in a Supplement issue of *Environmental Health Perspectives*, Gray and Bergbreiter (3) described the use of polymeric smart materials that have direct applications in reducing pollution from the chemical industry. Polymeric smart materials are substances that sense and respond to some change in their molecular environment in a controlled and reproducible manner. Because catalysts are used extensively in the chemical industry, failure to recover them from reactors can be a source of significant industrial waste. A partial solution was found in the use of smart catalysts. Thermoresponsive polymer-bound catalysts were developed and designed so that solubility was inversely related to temperature. Thus, catalysts can be recovered by a simple filtration step after an adjustment of the temperature of the reacting solution. As an added bonus, this type of catalyst could also be used to self-regulate exothermic reactions, i.e., as the temperature increased the solubility of the catalyst decreased, thus modulating the reaction.

Recognizing the importance of reducing pollution at its source, Congress passed the Pollution Prevention Act in 1990. In response, the U.S. Environmental Protection Agency (EPA) launched the green chemistry program (4); the program's goal was to promote the development of new or improved chemical products and processes that would be less hazardous to human health and the environment. Although the program is strictly voluntary, the EPA has now provided an additional incentive for industry to adopt green chemistry methods. Health and environmental risk issues have been added to the regulatory review of chemical processes that are proposed to be used in the manufacture of new chemicals.

Promoting the continual introduction of environmentally friendly products and production methods in the chemical industry was furthered with the announcement of the green chemistry challenge by President Clinton. This 2-year-old initiative was intended to recognize and promote fundamental and innovative technologies. The EPA has promoted the green chemistry challenge by creating awards and grants for innovative, nonpolluting chemical processes. These awards have been made possible by the joint efforts of many organizations, including the EPA, the American Chemical Society, the National Science Foundation, members of the chemical industry, and representatives from academia. The EPA hopes that the grant programs and awards will result in ideas for the development of chemical production methods with broad industrial applications that will also reduce pollution.

The first Presidential Green Chemistry Challenge Awards were announced last summer. Awards were made to Monsanto for a new method that reduces waste during the manufacturing of Roundup; to Dow Chemical for the substitution of carbon dioxide for chlorofluorocarbons in the making of polystyrene; to Rohm and Haas for development of a less-toxic boat paint; to Donlar Company for a process to substitute biodegradable thermal polyaspartate for polyacrylic acid; and to Mark Holtzapple of Texas A&M University for developing a technique to convert biomass waste to animal food. All of these innovations have the potential for greatly reducing pollution. For example, the implementation of the Donlar Company method could have a major impact on our landfill problems because polyacrylic acid is a key compound in manufacturing disposable diapers. The extent of that impact becomes clearer when we realize that this one consumer item currently makes up about 2% of solid waste in landfills in the United States (5). Recently, it was reported that Bayer will be building a 2,000-lb pilot plant to produce polyaspartic acid (6).

Richard Lipkin received the American Chemical Society's 1997 James T. Grady-James H. Stack Award for Interpreting Chemistry for the Public. In his acceptance speech, he was quoted as saying that chemists "believe the world is beautiful, magical, and knowable" (7). This wonder of science of which Lipkin writes will endure, but it will only be with the concerted effort of its practitioners toward pollution prevention that the world will be able to retain its beauty and magic. The above examples give us hope.

The American Chemical Society proclaims that "chemistry is not the problem, it's the solution." Perhaps to steer our future chemists on the proper course we need a green version of Gilbert's famous chemistry sets.

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